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(54) Title: IMPROVED METHOD FOR STORING CONTACT LENSES

(57) Abstract

A method of storing contact lenses using a lens case having a bactericidal coating and a storage solution containing a quaternary ammonium compound.

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IMPROVED METHOD FOR STORING CONTACT LENSES

Background of the Invention

The present invention relates to a method of storing contact lenses and more particularly to a method for storing and disinfecting contact lenses.

A typical contact lens wearer will periodically remove his or her contact lenses, either to store the lenses or to clean and disinfect the lenses. Even wearers of disposable contact lenses are known clean or disinfect their lenses and use the lenses longer than the manufacturer's recommended time period. During this storage period, many researchers have noted that the lenses are susceptible to colonization by a variety of microorganisms, and this problem exists even when the lenses are stored in a disinfecting solution containing hydrogen peroxide, chlorhexidine, biguanides or quaternary ammonium compounds. While the most serious infection associated with contact lens use may be microbial keratitis, contamination of the lens care system could lead to production of toxins that can affect the eye. The protective mechanisms of the eye, such as the flushing action of the tears, may protect most patients from developing corneal infections, but the use of extended wear contact lenses may disrupt these natural protective mechanisms, perhaps explaining the higher frequency of corneal infection noted by researchers with extended wear lenses.

One possible explanation for the colonization of contact lenses while in storage despite the presence of a disinfectant, is the existence of a biofilm in the contact lens storage case. Biofilms may form when bacterial cells attach to the interior surfaces of the lens case. Exopolysaccharides, also known as glycocalyx, produced by the bacterial cells, firmly glue the cells to the lens case surface. Subsequent cell divisions inside the glycocalyx matrix produce microcolonies, which eventually coalesce to form microbial biofilms. Growth of microorganisms within the biofilms can be very difficult to control and bacteria can be spontaneously released into the contact lens storage solution over time.

One suggested solution to the problem of biofilm formation in contact lens cases is the addition of an anti-adherent or bactericidal surface coating to the

interior of the case. Such a coating could include thin film layers of platinum, palladium, iridium, gold, silver, mercury, copper, zinc, germanium and other Group 3 through Group 16 metals and alloys, as well as compounds and oxides thereof. While such coatings have proven useful in reducing bacterial growth with the contact lens case system, these coatings alone have not eliminated contamination of the solution within the contact lens case.

Accordingly, a need continues to exist for an improved method of storing contact lenses that reduces bacterial growth within the contact lens storage case system.

Brief Description of the Invention

The inventors of the present invention have surprisingly discovered that the use of a bactericidal coating on the interior of the contact lens case in combination with a storage solution containing a quaternary ammonium compound has enhanced bactericidal efficacy.

Accordingly, one objective of the method of the present invention is to reduce the formation of microbial biofilms in contact lens storage cases.

Another objective of the method of the present invention is to reduce colonization of contact lenses during storage.

These and other objectives and advantages of the present invention will become apparent from the detailed description and claims which follow.

Detailed Description of the Invention

The inventors have discovered that a bactericidal coating on the interior surface of contact lenses cases alone may not be sufficiently effective at preventing the formation of biofilm within the case. In addition, as discussed above, the use of a storage solution having a disinfectant in an uncoated case does not prevent the formation of biofilm, and the solution in the case may become contaminated over time. The inventors have surprisingly found that a contact lens case with a

silver coating in combination with a solution containing a quaternary ammonium compound has enhanced bactericidal effect.

The mechanism that produces such surprising results is not fully understood, and while silver is the preferred coating, it is believed that other coatings, such as platinum, palladium, iridium, gold, mercury, copper, zinc, germanium and other Group 3 through Group 16 metals and alloys, as well as compounds and oxides thereof, may also produce surprisingly effective antimicrobial activity when used in combination with a solution containing a quaternary ammonium compound. While any suitable deposition method may be used to form the coating on the lens case, the examples discussed below used ion beam assisted deposition as more fully described in U.S. Patent Application Serial No. 07/663,361 and published PCT Patent Application No. WO 93/07924 (International Patent Application No. PCT/US92/08266), the entire contents of both of these patent applications is incorporated herein by reference, and suitable contact lens cases are commercially available from Spire Corporation, Patriots Park, Bedford, Massachusetts 01730. Preferably, an ion implanter such as that disclosed in U.S. Patent No. 4,693,760 is used. Preferably, at least about 1×10^{15} ions per cubic centimeter are implanted at a depth of between approximately 0.01 microns to 2.0 microns. Other suitable coating methods are disclosed in U.S. Patent Nos. 4,855,026, 4,872,922, 4,152,478 and 4,281,029; the entire contents of these patents are incorporated herein by reference.

Suitable disinfecting solutions are more fully described in U.S. Patent Nos. 4,407,791 (Stark), 4,525,346 (Stark) and 5,037,647 (Chowhan, et al.) and are commercially available from Alcon Laboratories, Inc., Ft. Worth, Texas 76134 under the trademark OPTI-FREE®.

EXAMPLE 1

Serratia marcescens was cultured on agar slants. Surface growth was harvested with saline solution and the microbial challenge suspension was adjusted to a 1.0×10^{8} CFU/mL concentration using a spectrophotometer. The wells of thermoplastic contact lens cases that were either uncoated or had a silver

coating were filled with sterile saline solution and a test solution containing 0.001% by weight of a polymeric quaternary ammonium compound (polyquaternium-1). The sterile saline and the test solution contained the challenge microorganism at a final concentration of 5.0×10^5 - 1.0×10^6 CFU/mL. The well lids were replaced and the lens cases stored at room temperature for the duration of the test.

At selected time intervals, the solutions in the case wells were mixed and a 1 ml aliquot was removed. Decimal dilutions of the solution were made in neutralizing broth and pour plates prepared with neutralizing agar. The well surfaces were swabbed and plated after the last time interval.

Plates and dilution tubes were incubated at 30°-35°C for 48-72 hours. The plates and dilution tubes were observed for growth and the number of survivors was determined according to standard microbiological methods.

Table 1 illustrates the Log_{10} reduction of survivors from Example 1:

TABLE 1

Cycle No.	Time (Hrs.)	0.001% Polyquaternium-1 Solution		0.9% NaCl Solution	
		Coated	No Coating	Coated	No Coating
1	6	1.6	0.7	0.1	0.1
	24	<u>6.2</u>*	2.1	1.1	0.0
5	6	1.6	0.7	0.1	0.0
	24	4.3	2.1	0.2	-0.3
10	6	3.0	0.8	0.0	-0.1
	24	5.6	2.6	1.2	-0.2
20	6	<u>6.2</u>*	1.0	0.7	-0.3
	24	<u>6.2</u>*	3.0	2.6	-0.4

*Underlined numbers indicate that no survivors were recovered.

EXAMPLE 2

Serratia marcescens was cultured on agar slants. Surface growth was harvested with saline solution and the microbial challenge suspension was

adjusted to a 1.0 x 10^8 CFU/mL concentration using a spectrophotometer. Thermoplastic contact lens case bowls were filled with sterile saline solution and a test solution containing 0.001% of a polymeric quaternary ammonium compound (polyquaternium-1). The sterile saline and the test solution contained the challenge microorganism at a final concentration of 5.0 x 10^5 - 1.0 x 10^6 CFU/mL. Thermoplastic lens storage baskets that were either uncoated or had been coated with silver were placed in the bowls and the lens cases stored at room temperature for the duration of the test.

At selected time intervals, the solutions in the case bowls were mixed and a 1 ml aliquot was removed. Decimal dilutions of the solution were made in neutralizing broth and pour plates prepared with neutralizing agar. The lens basket surfaces were swabbed and plated after the last time interval.

Plates and dilution tubes were incubated at 30°-35°C for 48-72 hours. The plates and dilution tubes were observed for growth and the number of survivors was determined according to standard microbiological methods.

Table 2 illustrates the Log_{10} reduction of survivors from Example 2.

TABLE 2

Cycle No.	Time (Hrs.)	0.001% Polyquaternium-1 Solution		0.9% NaCl Solution	
		Coated	No Coating	Coated	No Coating
1	6 24	4.8 <u>6.5</u>*	0.8 2.5	0.8 3.2	0.0 0.1
5	6 24	2.5 <u>6.3</u>*	1.0 2.5	0.3 1.7	-0.2 -0.3
10	6 24	2.0 <u>6.3</u>*	0.9 2.9	0.2 2.2	-0.4 -0.4
20	6 24	<u>6.2</u>* <u>6.2</u>*	0.6 2.2	0.4 3.1	-0.5 -0.5

*Underlined numbers indicate that no survivors were recovered.

As can be seen from the data contained in Tables 1 and 2, the use of a silver coating, either on the lens holding basket or on the lens case well, in combination with a solution containing a quaternary ammonium compound was surprisingly more effective in reducing the number of *Serratia marcescens* than either the coated case alone or the quaternary ammonium containing solution alone. In fact, the reduction in survivors of this combination was surprisingly substantially greater than the sum of the survivor reduction with the case alone added with the survivor reduction with the quaternary ammonium solution alone. While the inventors predicted some additive effect of the combination, the exponential increase in survivor reduction was unexpected.

This description is given for purposes of illustration and explanation. It will be apparent to those skilled in the relevant art that changes and modifications may be made to the invention described above without departing from its scope or spirit.

We claim:

1. A method of storing a contact lens, comprising the steps of:

a) providing a lens storage container with an interior having an interior surface coated with an antimicrobial coating, comprising Group 3 through Group 16 metals, alloys, as well as compounds and oxides thereof;

b) at least partially filling the interior with a lens storage solution containing a quaternary ammonium compound; and

c) inserting the contact lens into the solution within the interior.

2. The method of claim 1 wherein the coating comprises silver.

3. The method of claim 1 wherein the quaternary ammonium compound comprises polyquaternium-1.

4. The method of claim 1 wherein the interior surface comprises a well formed in the contact lens storage container.

5. The method of claim 1 wherein the interior surface comprises a lens holding basket that is received by the lens storage container.

6. A method of storing a contact lens, comprising the steps of:

a) providing a lens storage container with an interior having an interior surface coated with at least silver;

b) at least partially filling the interior with a lens storage solution containing polyquaternium-1; and

c) inserting the contact lens into the solution within the interior.

7. The method of claim 6 wherein the interior surface comprises a well formed in the contact lens storage container.

8. The method of claim 6 wherein the interior surface comprises a lens holding basket that is received by the lens storage container.

9. A method of reducing the formation of biofilm in a lens case having an interior, comprising the steps of:

a) coating an interior surface of the interior with an antimicrobial coating, comprising Group 3 through Group 16 metals, alloys, as well as compounds and oxides thereof; and

b) at least partially filling the interior with a solution containing a quaternary ammonium compound.

10. The method of claim 9 wherein the coating comprises silver.

11. The method of claim 9 wherein the quaternary ammonium compound comprises polyquaternium-1.

12. The method of claim 9 wherein the interior surface comprises a well formed in the lens case.

13. The method of claim 9 wherein the interior surface comprises a lens holding basket that is received in the interior.

14. A method of reducing the formation of biofilm in a lens case having an interior, comprising the steps of:

a) coating an interior surface of the interior with an antimicrobial coating, comprising at least silver; and

b) at least partially filling the interior with a solution containing polyquaternium-1.

15. The method of claim 14 wherein the interior surface comprises a well formed in the lens case.

16. The method of claim 14 wherein the interior surface comprises a lens holding basket that is received in the interior.